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EFFECTS OF DETERIORATED RANGE STREAMS ON TROUT

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ABSTRACT

Improper management of domestic livestock on western ranges has caused habitat degradation of trout streams in some areas. As a result, there is either less trout production or conditions have deteriorated to such a degree that the fish can not survive in the streams. To accommodate requirements of sportsmen for additional fishing opportunities and to achieve national objectives for better balance in managing resources, it is necessary for habitat degradation problems to be solved.

Livestock can alter the quality of stream habitat by damaging banks and decreasing the density of streamside vegetation. Bank damage, besides contributing to erosion and the alteration of channels, can eliminate important trout habitat associated with banks. When streamside vegetation is cropped unacceptably, erosion and sedimentation are promoted. If shading is decreased, water temperatures can elevate to levels unsuitable for trout. Sedimentation can lessen trout reproductive success and the production of aquatic insects which are the predominant food base.

Solutions to trout habitat problems will have to be achieved through inter-disciplinary efforts. Fishery biologists, watershed specialists, range management specialists, plant ecologists and other professionals must become collectively involved to perfect habitat improvement methods. It will be essential for the livestock industry to cooperatively assist land management agencies to improve stream conditions once suitable approaches are developed. ●

Introduction

With the dramatic increase in the [illegible]mber of sportsmen in the West, fishing pressures are intensifying and it is becoming more difficult for existing fisheries to satisfy sport fishing requirements. Consequently, resource managers are interested in improving conditions in streams to increase game fish populations for harvest by fishermen. Also, attention is being focused on accomodating environmental needs of fishery resources because of the establishment of national goals for better balance in resource management.

One opportunity for increasing fish numbers is that of improving degraded fish habitat associated with rangeland streams. Degradation has occurred in some areas because land management practices have not been implemented for protecting natural stream conditions. Resultingly, there are streams which once supported substantial game fish populations but [illegible]ow are marginal in quality for fish [illegible]duction or have deteriorated to a [illegible]ge that only undesirable non-game species can survive.

Fisheries problems attributable to livestock management practices are addressed in this paper. Information is not presented with the intent of criticizing livestock use of rangelands. Instead, the purpose is to stimulate a better understanding by range specialists, range managers and stockmen about impacts of abused stream habitat conditions on fish. Once an understanding is achieved, the next step will be cooperative efforts in solving existing problems. Trout are emphasized in the paper because in the West these fish receive the most public attention.

Problem

It is recognized by fisheries specialists that livestock has been responsible for damaging some rangeland trout streams. Symptoms for a stream in an impaired condition can include bank caving and sloughing, channel straightening and widening, decreased average water depth, a high percentage of bottom area with superimposed silt and sand and limited stream shading *(Figures 1 and 2)*. Deterioration occurs because of the effects of livestock congregating along streams. The behavior is attributable to preference of animals for shade, lusher vegetation, and readily available drinking water.

As an example of how habitat alteration can collectively have an adverse impact on trout, information reported by Marcuson (n.d.) is applicable.[1] In Rock Creek in Montana, populations of brown trout (Salmo trutta) were compared in a heavily grazed zone and in a natural area. Within the natural area there were 1,880 (213 pounds) of trout per acre compared to 701 (63 pounds) per acre where heavy grazing occurred. Weightwise, the standing crop was 3.4 times greater in the natural area and fish in excess of 8 inches long were 300% more abundant than in the heavily grazed zone.

For effects of overgrazing in general, Behnke and Zarn (1976) cite it as one of the principal factors contributing to the decline of native trout in the West. Their assessment is as follows: *"Grazing livestock may destroy the vegetative cover and cave in overhanging bank, thereby eliminating the most*

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[1] For this and other information cited conceptually in the text for trout/habitat interrelationships, readers are cautioned not to assume that quantitative data apply categorically to all streams. Each stream has to be evaluated individually prior to (a) determining adverse impacts which have occurred as a result of a given land-use practice, and (b) predicting fish population responses should habitat be improved.

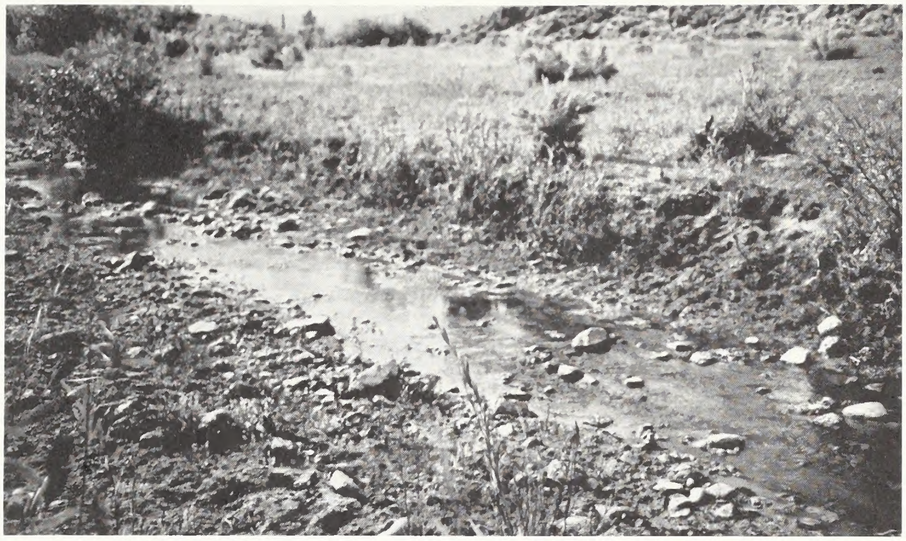

Figure 1. Stream habitat damaged by livestock in the Reynolds Creek watershed in southwestern Idaho. Note relatively sparse streamside vegetation, trampled banks, and channel widening. Stands of shrubs and trees near the stream are not dense as would prevail under normal conditions because replacement seedlings cannot establish. Plants in the bottomland background are predominantly curley cup gumweed (Grindelia squarrosa) considered to be an indicator of a disturbed range site. (BLM photo – Author)

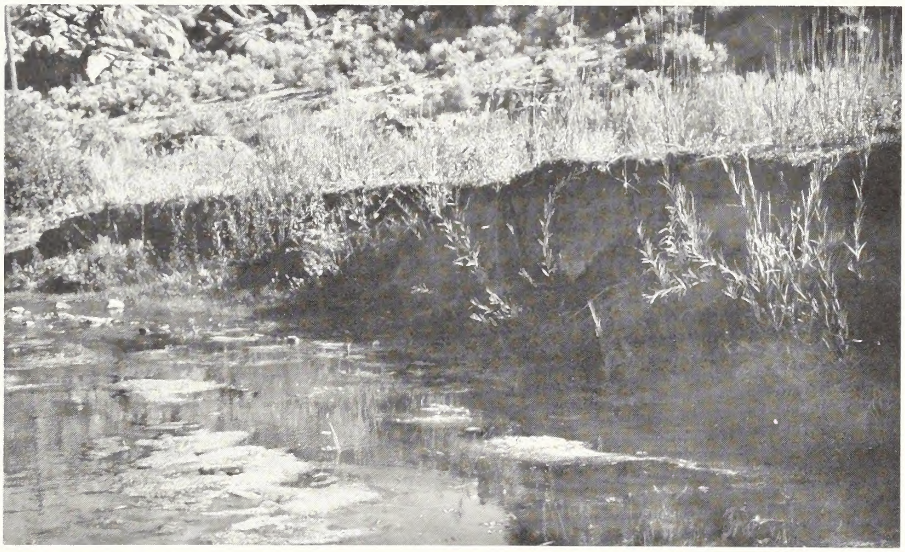

Figure 2. Streambank damage in the Reynolds Creek watershed in southwestern Idaho. The condition, which is aggravated by livestock trampling and cropping of forage, contributes to channel widening and sedimentation. After caving occurs, banks are susceptible to continuous sloughing. In addition to fish habitat being destroyed when banks are damaged, there is a gradual loss of valuable bottomland which lessens the carrying capacity for wildlife and livestock. (BLM photo – R.L. Lingenfelter)

important trout habitat. Loss of streambank vegetation leads to increased water temperatures, erosion and silting, elimination of spawning sites, and reduction of food supplies in the stream, all of which drastically degrade trout habitat.” Effects of habitat damage by livestock on trout are indicated in *Figure 3* and specifics are addressed as follows.

Effects of Sediment

Sediments settle into spaces between gravel in which trout eggs are incubated. As a result, intergravel water flow is impeded and developing embryos do not receive adequate quantities of dissolved oxygen which has an adverse impact on development and survival. Also, metabolic wastes of the embryos are not flushed which contributes to higher mortality rates. As an example of how sediment can impact trout, data of Peters (1962) was plotted to indicate approximate relationshi between mortality rates of incubati embryos of rainbow trout (Salmo gairdneri), different suspended sediment concentrations and intergravel water velocities *(Figure 4).* Mortality rates exceeded 75% when sediments elevated to 200 parts per million or greater. As suspended sediment concentrations increased, intergravel water velocities decreased, indicating gravel clogging.

Bjornn (1973), after conducting field work with steelhead trout (sea-run rainbows), reported that for sand and gravel mixtures, less than 25% of the eggs developed to the emergent fry[2] stage when sand concentrations approximated 30%, compared to an excess of 75% emergence in concentrations less than 20%. Work of Corley (1976) also related to effects of sediment on reproductive success *(Figure 5).* The quantity of fines (sediment less than 6.33 mm) was correlated to the approximate survi rate from the egg to fry stage in South Fork of the Salmon River Idaho. It was observed that survival decreased markedly when fines exceeded 20%.

It is important to maintain high reproductive success in streams because, even for normal conditions, natural mortality of trout from the egg to more advanced stages is pronounced. For an example, Shetter (1961) reported that for brook trout (Salvelinus fontinalis) mortality rates by the end of the first summer of life usually exceeded 90% of the original number of eggs laid.

Effects of Removal of Streamside Vegetation

Streamside vegetation in hot, arid areas typical of much of the western rangeland is extremely important for shading and maintaining tolerable temperature regimes. It is recognized by aquatic specialists that vegetation is extremely important factor influen summer water temperatures. For

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[2] Emergent fry are fish which hatch in spawning gravel and then exit from the gravel to enter the stream for completion of other life stages.

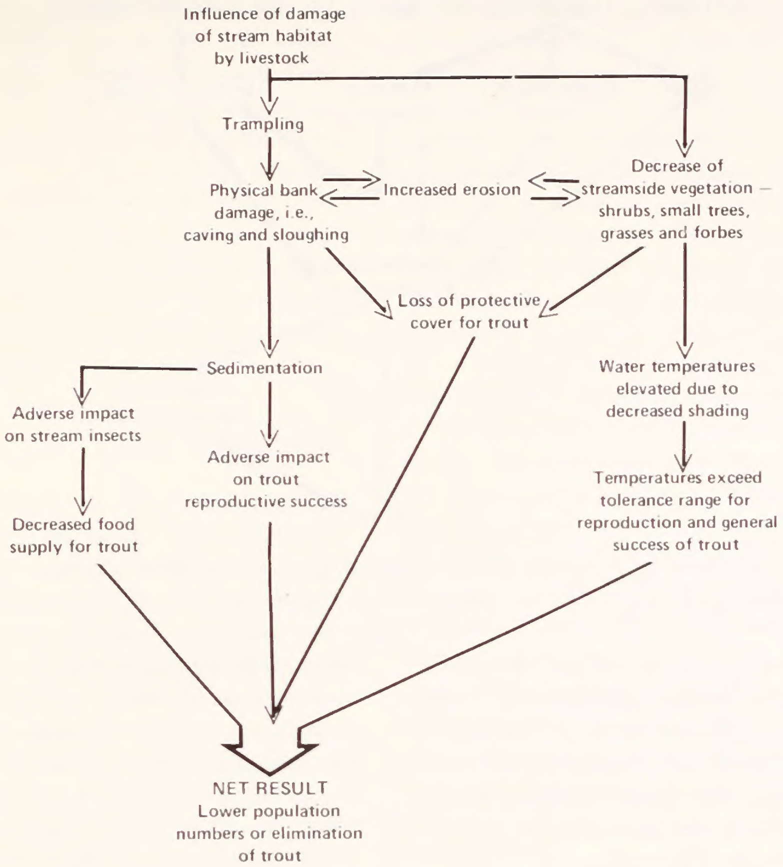
Influence of damage of stream habitat by livestock
Trampling
Physical bank damage, i.e., caving and sloughing
Increased erosion
Decrease of streamside vegetation — shrubs, small trees, grasses and forbes
Loss of protective cover for trout
Sedimentation
Water temperatures elevated due to decreased shading
Adverse impact on stream insects
Adverse impact on trout reproductive success
Temperatures exceed tolerance range for reproduction and general success of trout
Decreased food supply for trout
NET RESULT
Lower population numbers or elimination of trout

Figure 3. Conceptualized flow chart of adverse effects of stream habitat damage y livestock on trout populations.

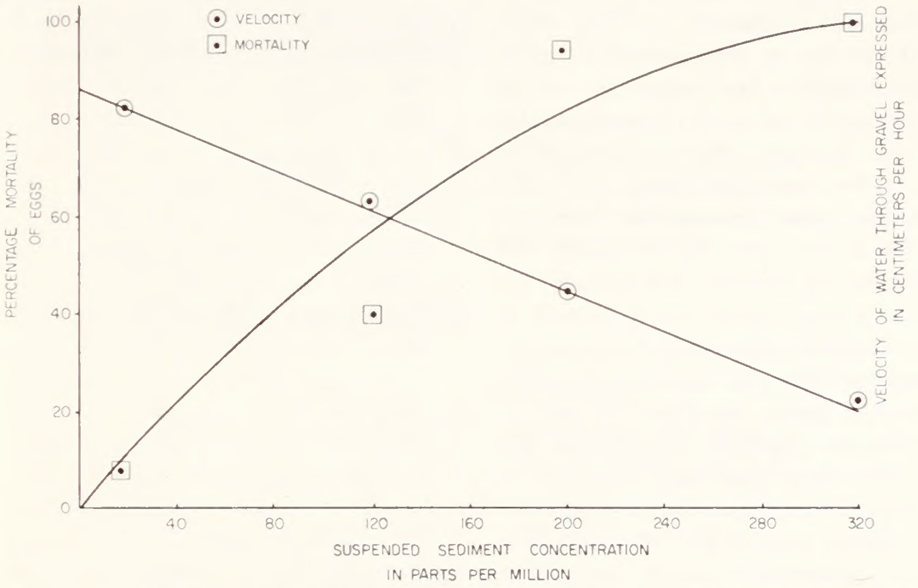

Figure 4. Relationships between suspended sediment concentrations, apparent intergravel water velocity, and mortality rates of rainbow trout eggs in Bluewater Creek, Montana. For the velocity plot, measurements were taken within the gravel. As suspended sediment concentrations increased, velocity decreased indi-ating sediment deposition and clogging of spaces between gravel. Data plotted om Peters (1962).

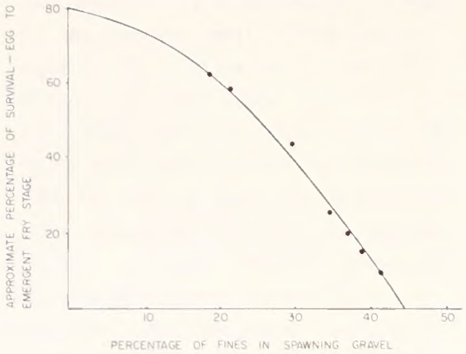

Figure 5. Survival of chinook salmon (Oncorhynchus tshawtscha) from the egg to fry stage in the South Fork of the Salmon River in Idaho correlated with fines (material smaller than 6.33 mm) in gravel (Corley, 1976). Salmon and trout have relatively similar environmental requirements.

example, monitoring was conducted in the Needle Branch of the Alsea River in Oregon and the highest recorded temperature was 61°F. After logging and removal of streamside vegetation, the maximum temperature exceeded 85°F. In succeeding years, temperatures lowered as vegetation became re-established (Lantz, 1971).

In general, for trout to be successful, temperatures should not exceed the mid-60's during summer periods. For critical phases of the life cycle, such as spawning and hatching, they are less tolerant *(Table 1)*. High temperatures can be lethal to trout directly, making them susceptible to diseases because of stress, inhibit reproductive success, and adversely affect spawning migrations (Lantz, 1971).

Water temperatures in small streams associated with rangelands commonly exceed 80°F when vegetation is eliminated by grazing, and conditions for trout become unsuitable. These streams are particularly susceptible to harmful temperature alterations because, as in logged areas, potential for change is directly proportional to the amount of stream surface area which becomes exposed and in-

Species	Optimum Range °F	Spawning Range °F	Hatching Range °F
Rainbow	54-66	36-68	55**
Brook*	47-52	38-45	39-54
Brown*	39-70	50**	36-52
Steelhead	45-58	39-49	50***
Cutthroat****	49-55	43-63	40-55

*Fall spawners.
**Optimum temperature.
***Preferred temperature.
****Salmo clarki.

Table 1. Temperature data for trout (Bell, 1973).

directly proportional to the discharge (Brown, 1973). The importance of vegetative cover is of such a high priority that some fisheries experts concerned about problems caused by livestock recommend that most small streams should have at least an 80% canopy to promote acceptable temperatures (Forest Service, 1977).[3]

In addition to temperature effects, streamside vegetation also provides cover for trout. This fact has been recognized for some time by fishermen and students of animal behavior. One investigator (Boussu, 1954) documented influences of cover in a small stream in South Dakota within experimental sections. The placement of cut brush by hand to simulate natural willow cover in density and position resulted in an increase of trout poundage by 258.1%.

Impacts of Habitat Alteration on Food Organisms

Trout in streams are normally dependent on aquatic invertebrates (predominantly insects) for nourishment, which has been verified by Griffith (1974), who examined stomach contents of brook and cutthroat trout in four Idaho streams. He reported that members of five aquatic insect orders comprised approximately 92% of the number of organisms eaten by the fish.

As indicated in *Figure 3,* sedimentation can adversely impace insects (Cordone and Kelley, 1961). Sediments are harmful because of abrasive actions and interference with functioning of respiratory organs. Also, the material settles over the most productive substrates, such as rubble, which reduces quality insect-producing habitat. The net result of sedimentation to insects can be the lessening of their diversity and production which impairs the food quality of a stream for trout.

Even if sedimentation does not become a problem, it is possible that removal of bankside vegetation can have an adverse impact on food supplies of insects. In a stream, terrestrial vegetation can be the predominant food base of the organisms. If inadequate amounts of material fall or wash into a stream, the ultimate impact in the food chain can be a decrease in trout production *(Figure 6).*

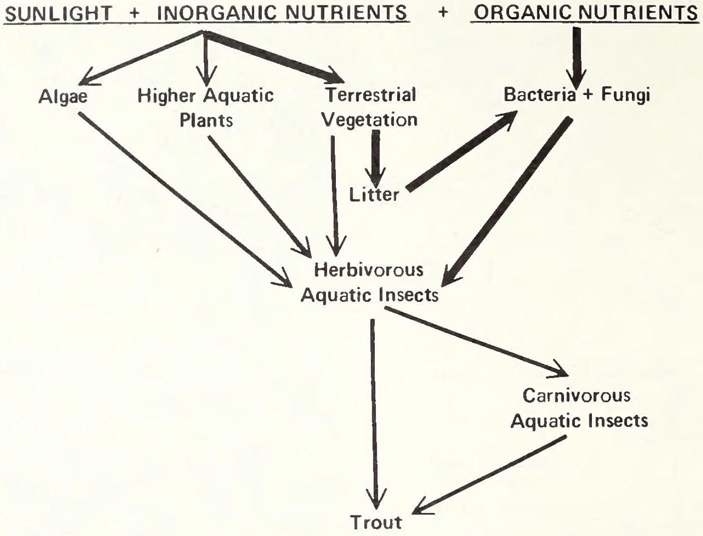
SUNLIGHT + INORGANIC NUTRIENTS + ORGANIC NUTRIENTS
Algae
Higher Aquatic Plants
Terrestrial Vegetation
Bacteria + Fungi
Litter
Herbivorous Aquatic Insects
Carnivorous Aquatic Insects
Trout

Figure 6. Major pathways in the trout food chain for a hypothetical range stream. Modified after Mundie (1974). Heavier lines represent greater rates of energy flow.

Types of Responses for Streams Managed for Improved Habitat

If aquatic habitat is enhanced for degraded rangeland streams, there should be an improvement in trout populations. The magnitude of responses in terms of increased population numbers would be related to (1) the degree and quality of habitat enhancement achieved; (2) the size of the stream; and (3) its original fish supporting capacity. The recovery time for a given stream would depend on the type of management implemented, composition and stability of existing stream banks, the degree of degradation, soil moisture relationships, and water runoff patterns within a watershed. Types of predictive changes for a stream transformed from a degraded to a recovered phase are indicated in *Figure 7.* After recovery, improved conditions for fish success would be associated with (1) a deeper average water depth; (2) flushing of silt and sand to expose gravel, rubble, and rock bottoms; (3) stabilized banks due to vegetative cover; (4) bank undercutting to provide additional cover for fish; (5) overhanging vegetation to shade and keep water temperatures lower during hot periods of the year; and (6) a tendency for a more favorable combination of pools and riffles to develop. As an example how a stream can respond to management, data of Hunt (1971) is pertinent. The author measured specific parameters of a brook trout stream during a three-year period after stream improvements were installed. Responses as indicated i *Figure 8* were recorded. Importa changes included less silt (70%) and sand (40%) covered bottoms, more pool areas (289%), a 416% increase in permanent bank cover and a substantially increased yield to fishermen.

As an example of how fish populations have responded to improved habitat conditions as a result of improved livestock management practices, events for Otter Creek in western Nebraska are cited (Van Velson, n.d.). By the mid-1950's the rainbow trout population in the creek had been virtually eliminated because of impaired habitat conditions. Problems included sediment deposition on spawning areas, bank erosion, and poor pool quality. The headwater area of the creek was leased in 1969 by the Nebraska Game and Parks Commission and fenced to exclude livestock. Within three years, the stream had improved to become a major rainbow trout producer. The author reported that: *"The averag width of the stream was decreased places. Untrampled stream bank quickly stabilized, providing protection and resting areas for trout. More important, however, fencing protected the watershed from flooding, and sand*

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[3] The group authoring the report was comprised of aquatic specialists from the academic community and Federal agencies attending a livestock and wildlife-fisheries workshop. A report in preparation will be published by the Forest Service, Pacific Southwest Forest and Range and Experiment Station.

no longer drifted in to smother the gravel beds. Deep pools and clean gravel quickly appeared in the stabilized stream. The water temperature during the critical summer months was reduced 2 to 5 degrees, another benefit of stream fencing." In 1975, it was estimated that in approximately two miles of the fenced creek with 3.34 surface acres of water, 20,419 smolts (young migratory fish) were produced (Van Velson, personal communication, December 22, 1977).

Present Range Manager Predicaments

A range specialist seemingly has only three choices for management of a degraded stream. He can elect to (1) permit existing grazing conditions to prevail and risk additional deterioration; (2) manage exclusively for quality fish habitat; or (3) implement a livestock management program which will help improve the stream to some acceptable level of trout production. Because of intensified public demands for better balance in approaches for resource management, it will become increasingly unlikely that option one (continue with existing conditions) will be a viable alternative. Therefore, there must be a trend toward achieving improved fish habitat. This poses a formidable problem because range specialists have failed to be active in developing innovative methodologies for improving habitat damaged by livestock. When a management decision is made to improve habitat conditions for fish, the only recourse at the present time is usually that of fencing a degraded stream to exclude livestock. Although habitat usually recovers dramatically after fencing, it is quite expensive and has other drawbacks. It is estimated that fencing costs for both sides of a stream per linear mile range from $2,000 to $6,000, and there are annual maintenance costs thereafter for repairing normal and intentionally-caused damage. Expenses such as those for services of a fence rider during the grazing season can also be incurred in some areas. Additionally, if a stream is fenced and the carrying capacity of the range outside the stream zone cannot support additional grazing, the stocking density for livestock has to be reduced or range improvement projects designed to provide additional forage have to be implemented.

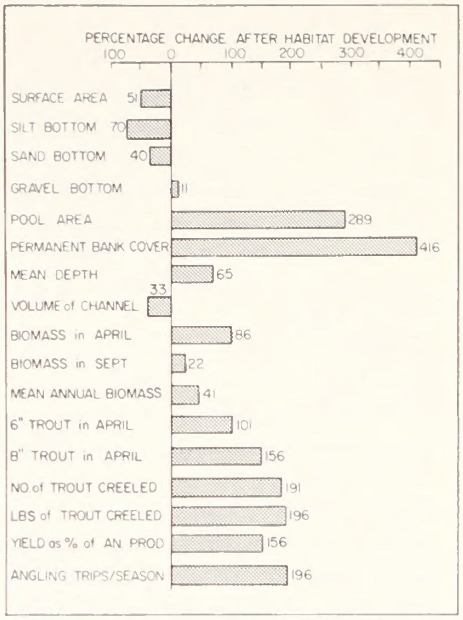

Figure 8. Recorded changes in characteristics in a 1.5 mile segment of Lawrence Creek in Wisconsin during a three-year period after stream improvement devices were installed (Hunt, 1971). For a range stream recovering naturally after management is implemented to improve habitat, it is predicted that similar types of changes would occur. Time requirements and magnitudes of change would vary on a stream-specific basis. Biomass changes in the figure refer to brook trout.

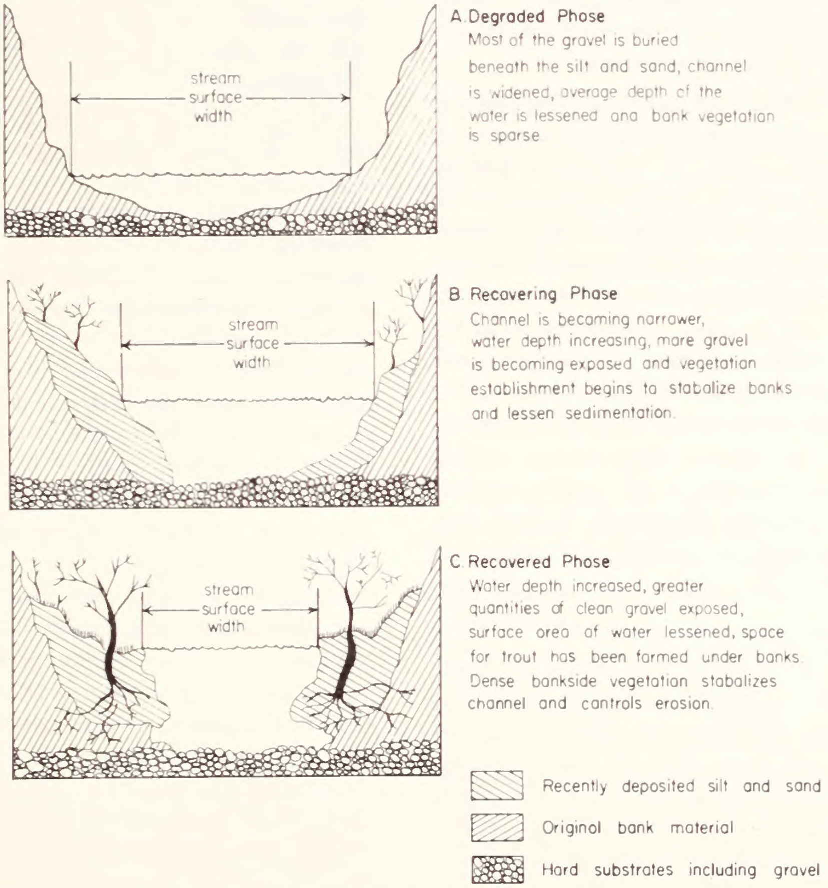
stream surface width
A. Degraded Phase
Most of the gravel is buried beneath the silt and sand, channel is widened, average depth of the water is lessened and bank vegetation is sparse
stream surface width
B. Recovering Phase
Channel is becoming narrower, water depth increasing, more gravel is becoming exposed and vegetation establishment begins to stabalize banks and lessen sedimentation.
stream surface width
C. Recovered Phase
Water depth increased, greater quantities of clean gravel exposed, surface area of water lessened, space for trout has been formed under banks. Dense bankside vegetation stabalizes channel and controls erosion.
Recently deposited silt and sand
Original bank material
Hard substrates including gravel

Figure 7. Conceptualized cross-sectional characteristics of a stream in degraded, recovering, and recovered habitat phases. For the Phase A condition, pool and riffle relationships are disrupted. In effect, there is a tendency for channeling to occur which lessens the abundance and quality of pools. For Phase C, note undercut areas which eventually develop. If bank damage occurs, this important trout cover is usually the first to be destroyed and years can be required for natural restoration. Adapted from White and Brynildson (1967).

The loss of forage for livestock can often be inconsequential, however, because it is usually necessary to fence off only a few feet along each stream bank. Also, there is evidence that as habitat recovers and water depth increases as a result of channel narrowing, the water table elevates. As a result of water table improvement, vegetation production can be stimulated adjacent to a fenced area to compensate for forage not accessible for grazing. Additionally, stream bank stabilization lessens erosive losses of productive bottomland which has a long term benefit of retaining grazing land for livestock.

In addition to fencing, it has been advocated that rest-rotation grazing[4] can be implemented in degraded areas to promote restoration of stream habitat for trout, but published evidence to support the supposition is lacking. Also, there is controversy associated with rest-rotation because there are professionals who categorically question suitability of the system for materially improving fish habitat, particularly for badly degraded sites in arid locations. Part of the negativism is attributed to observations that during use periods livestock continue to congregate along streams where they severely utilize vegetation, and trample banks prior to grazing areas farther away from water. Stream banks thusly are impacted each year grazing occurs and recovery is impeded.

Besides the concern that rest-rotation will not permit desirable streamside vegetation conditions to develop, it is suspected trout habitat under banks *(Figure 7)* will also not be restored. Habitat associated with banks is important for trout as was documented by Boussu (1954). He destroyed submerged pockets and then recorded responses of fish. In an altered area, the decrease of the standing crop poundage was approximately 33.3%. Biomass in a control section increased 19.7% during the same sampling period.

In respect to effects of grazing per se on areas associated with water, Hormay (1970) commented about the subject. The following quotations were in a personal communication dated September 1, 1976. *"Vegetation in certain areas, such as meadows and drainage ways, are invariably closely utilized under any stocking rate or system of grazing. Such use may be detrimental to wildlife, esthetic or recreational or other values. Where this is the case, about the only way to preserve values is to fence the area off from grazing. Reducing livestock or adjusting the grazing season usually will not solve such a problem."*

For option two (manage exclusively for quality fish habitats), a trend to maintain all stream habitat in this condition is improbable. However, for some streams this approach should be exercised, i.e., for those (1) supporting rare, endangered, or sensitive species; (2) which provide uniquely favorable habitat necessary for an important phase of a life cycle of a preferred species, such as steelhead trout; (3) with an existing or a potential fishery in geographic areas where sport fishing opportunities are limited; (4) designated for special activities such as ecological research and public water supply; (5) which presently are vitally important for maintaining sport fishing recreational demands; and (6) quality streams which currently are underfished but are projected to receive heavier use in future years.

Solutions for Stream Habitat Degradation Problems

Before it will be possible to implement widespread management to solve stream habitat problems, challenging subjects including the following will have to be addressed:

1. Which site-specific grazing systems are practical for improving fish habitat? When systems are designed it will be necessary to define techniques for management approaches for specific streams or watersheds. It will be unlikely that any one grazing system can be categorically applied to all sites.
2. Once improved management is implemented, what will be the predicted time for stream habitat to recover on a stream-specific basis? If it is predicted that recovery would require a long time, inexpensive stream improvement devices could possibly be installed to accelerate recovery or to enhance conditions for trout on an interim basis.
3. What techniques, exclusive of permanent fencing to exclude livestock, could be devised to promote recovery of damaged habitat? For example, would it be possible to establish plants unpalatable to livestock on badly eroded and damaged banks to expedite recovery? Would it be possible to perfect inexpensive, easily maintained devices to prevent livestock access to localized damaged areas of a stream to hasten habitat improvement?

Similar questions to those above, in addition to one about how different classes of livestock affect aquatic habitat, have been posed by Platts and Meehan (1977).

Prior to stream habitat probl[illegible] being solved it will be necessary [illegible] research efforts to be expanded. The research must include meaningful evaluations of grazing systems on streams for a variety of site characteristics.

Where it is not practical to improve degraded habitat for the benefit of fish, mitigative approaches could possibly be developed. For example, it might be desirable to manage some watersheds to achieve water quality objectives instead of striving to markedly improve fish habitat. Then reservoirs could be established in these areas to be managed exclusively for fish production and sport fishing.

Conclusions

Trout are adversely affected by factors such as sedimentation, physical bank damage, and loss of protective cover, as a result of improper livestock management.

One of the major impacts of [illegible]mentation is the impairment of re[illegible]ductive success of trout. The material which deposits in spaces between spawning gravel where eggs are incubated results in clogging which hampers embryo development by limiting oxygenation and flushing of metabolic wastes. Even if eggs do develop under such conditions, hatched fish can be prevented from emerging from gravel to complete other phases of their life cycle. Sediments can also lessen the production of aquatic insects which are the food base of trout. The material harms insects by direct abrasive actions and interference with functioning of respiratory organs. Additionally, important insect-producing habitat such as rubble is covered by sediment.

Physical bank damage, in addition to accelerating erosion and sedimentation, results directly in the destruction of important trout habitat under banks. Once banks are damaged, the cross-sectional profile of a stream is al[illegible] which results in poorer quality [illegible] habitat. Water depth is decreased because of channel widening, favorable pool and riffle relationships are disrupted and there is a tendency for greater quantities of sediments to deposit which decreases the abundance of suitable spawning gravel.

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[4] Rest-rotation can have various patterns. For a given pasture in a three-pasture system, there could be early spring use the first year, grazing from seed-ripe time until fall the second, and resting the third year.

When streamside vegetation is eliminated by livestock, besides losing protective overhead cover for trout, there is less shading. In hot, arid areas common for much of the range lands, shade loss can result in water temperatures rising to levels unsuitable for trout.

Presently, range managers are at a disadvantage because, other than the fencing of streams to exclude livestock, there are few known practical practices which can be implemented to improve or maintain quality habitat for trout. Because of the establishment of national goals for achieving better balance in resource management and to accomodate needs of sports fishermen, the habitat of some range streams will be managed exclusively for quality trout production. For other streams, programs will be implemented to improve habitat to some acceptable level of trout production.

If management objectives are to be achieved, it will be necessary for existing habitat problems to be solved through inter-disciplinary efforts. Fishery biologists, watershed specialists, range management specialists, plant ecologists, individuals from other disciplines and management will have to get actively involved. It will be essential that the livestock industry cooperate and assist land management agencies to improve stream conditions once viable techniques are developed.

Prior to widespread implementation of management approaches for solving habitat problems, challenging subjects including the following must be addressed:

- Which site-specific grazing systems are practical for improving fish habitat?
- If livestock management approaches can promote improvement of habitat but extended periods of time are required, what can be done to accelerate habitat recovery or to enhance conditions for trout on an interim basis?
- Which techniques, exclusive of permanent fencing to exclude livestock can be devised to promote habitat recovery?

The success of programs designed to restore habitat quality of trout streams will depend on cooperative efforts. Once habitat is improved results can be mutually beneficial to sports fishermen and the livestock industry. ● ● ●

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